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ABSTRACT

The data presented in this report call attention to inappropriate use of the Eigenroot criterion in factor work, a practice which has probably grown out of a theoretical focus on determining basic laws of behavior, rather than a practical emphasis on providing information that will be useful to college instructors and administrators. When researchers have sought only the general, broad dimensions that occur in Course-Instructor Survey (CIS) ratings, instructors and administrators have concluded that only these larger factors are needed in describing the evaluation of courses and instructors. In reality, however, administrative decision making and the provision of comprehensive feedback to instructors may demand that more specific factors be identified. In such cases, the proportion of variance criterion for stopping factoring may reveal information which would be lost were the Eigenroot criterion applied without regard to variance extracted. The question of when to stop factoring, then, seems to be best answered in terms of whether general laws of behavior are sought, or basic dimensions for specific practical applications are desired. (Author/JB)

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SOME METHODOLOGICAL CONSIDERATIONS IN THE USE OF FACTOR ANALYSIS TO DETERMINE DIMENSIONS UNDERLYING STUDENT RATINGS OF COURSES AND INSTRUCTORS

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Within the past few years, factor analytic techniques have been used with increasing frequency in research related to student ratings of courses and instructors. The method has proved useful in the summarization of such data both for purposes of description and interpretation, and for subsequent use in the development of rating instruments. The results of a factor analysis, however, always depend to some extent on such contingencies as characteristics of the data input and experimenter judgments at various points in the analysis. Although standard answers to such questions as the number of factors to be extracted or rotated have been offered, such judgments should not be applied uncritically. The current study compares and evaluates certain factor analytic procedures commonly employed in research related to students' ratings of courses and instructors.

More specifically, the study reported here sought to determine:

(1) the comparability of factor structures when (a) individual students' responses were used as the raw data input, and when (b) mean class responses formed the data base; and

(2) the effects of two stop-factoring criteria on the factor structures obtained with each of the above data bases, that is, (a) the extraction of all factors with latent roots above 1.00, versus (b) the

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continuous extraction of factors until about 70-75% of the variance is accounted for, or until the reliable variance has been extracted.

Data Source

The data analyzed here are responses to 33 items on the 40-item Course-Instructor Survey (CIS) General questionnaire which are specific to ratings of courses and instructors. (The first seven items on the questionnaire, requesting data concerning student raters, were not analyzed.) Responses were coded on a 1 to 5 scale, with 1 representing the most favorable response. The 33 items were:

8. The instructor seemed to be sensitive to the feelings and needs of students.

9. The instructor seemed well-prepared for lecture or discussion.

10. The instructor showed a scholarly grasp of the course material.

11. The instructor showed confidence before the class.

12. The instructor paced the course well.

13. The instructor kept his lectures and class discussions focused on the subject of the course.

14. The instructor usually seemed to be aware of whether the class was following his presentation with understanding.

15. The instructor used clear, relevant examples.

16. The instructor's mannerisms or habits reduced the effectiveness of his teaching.

17. The instructor's speech and lecture style contributed to his teaching effectiveness.

18. The instructor made me feel free to ask questions, disagree, and express my ideas.

19. The instructor was intellectually stimulating (thought-provoking, or caused me to do additional studying on my own.)

20. The instructor showed a genuine interest in teaching the course.

21. The instructor was generally accessible to students outside of class.

22. The instructor gave adequate instructions concerning assignments.

23. The instructor commented informatively on tests and assignments.

24. The tests were usually graded and returned promptly.

25. I was satisfied with the way the performance of students was evaluated in this course.

26. The textbooks were adequate for this course.

27. The reference books and materials in the library were adequate for this course.

28. I feel that I profited from the out-of-class assignments.

29. I feel that I profited from the laboratory (or discussion section) for this course.

30. Before the semester began, I thought I would enjoy this course.

31. Before the semester began, I thought this course would be of value to me.

32. At this point in time, I feel that this course will be (or has already been) of value to me.

33. The amount of outside preparation required for this course was:

34. For each hour of class, the average amount of time I spent on this course outside of class was about:

35. Compared with the effort I usually put into a course, my effort in this course was:

36. I met with the instructor outside of class to discuss the course:

37. I was absent from class:

38. Compared with all the instructors I have had, both in high school and in college, this instructor was:

39. Compared with all the courses I have had, both in high school and in college this course was:

40. Compared with what I expected to get from this course, I feel I got:

All of the 5,619 CIS forms completed by students in English Department courses during the Fall 1971 semester were used in the analysis. The survey included 294 courses, taught by faculty and teaching assistants, both at the undergraduate and graduate levels. Participation in the survey, although urged by the University administration and by the English Department, was voluntary on the part of the instructors. The surveys were administered under established conditions by a student member of each class during one of the last regularly scheduled class meetings. According to CIS procedures, the instructor is asked to leave the room while the students complete the form, and students responded anonymously.

Method

Individual students' responses to the 33 items were intercorrelated and a principal components factor analysis was performed using Computer Program FACTOR (Veldman, 1967, 1971). Since not all students answered all questions, the missing-data option available with FACTOR was utilized, when individual students' ratings were analyzed. The correlation matrix input to the factoring routine therefore consisted of coefficients computed only for valid score pairs, or for students responding to both items of the pair being correlated.

The principal components analysis was then performed on this matrix of item intercorrelations, with the initial values in the principal diagonal being set equal to 1.00. The initial analysis was performed for the extraction of only the principal components with corresponding latent roots greater than 1.00, as recommended by Kaiser & Caffrey (1965).

The same analyses were then performed using the average class responses of the 294 participating classes on each item, and the solutions for the two data bases were then compared by re-rotation using Program RELATE

(Veldman, 1967, 1969, 1971). First, a factor cosine matrix representing the relative proximity of the factors defined from the two data bases was obtained. Then, the Varimax factors computed from the class mean responses were re-rotated to conform as closely as possible to the target solution based on individual students' responses. Finally, a variable cosine matrix was computed which describes the relationship between individual item vectors in the target solution and the re-rotated solution based on class mean data.

In order to test the Eigenroots of 1.00 criterion, which has become something of a "blind" standard in much factor work, subsequent factor analyses were performed utilizing an approach in which factors are extracted until a desired portion of the total variance has been accounted for. This technique has been discussed by Guertin and Bailey (1970), Harman (1960), and Horst (1968), and appeared to offer a viable alternative to the Eigenroots criterion, particularly in consideration of the relatively high reliability of instructor rating forms. In the current study, a solution was sought which would account for about 70 to 75% of the variance, a figure based on reliabilities obtained for this and similar rating scales. Analyses extracting increasing numbers of factors beyond six were performed for both data bases, then, until the percentage of variance criterion had been reached. Results of the factor solutions obtained using each criterion for stopping factoring were then compared.

Results

When all latent roots above 1.00 were extracted, the factor analyses for both individual item responses and mean class responses yielded six factors. The Varimax loadings for these solutions are shown in Tables 1 and 2. There were, however, some differences discernible between the two sets of loadings. The diagonal elements in the cosine matrix shown in

Table 3 indicate that, while Factors II, III, and IV are quite close for the two solutions, Factors V and VI, and to a lesser degree, Factor I, seem to differ for the two data bases. By inspecting the primary loadings (underlined in Tables 1 and 2) for the two solutions, it can be seen that Factors V and VI seem simply to have occurred in reverse order for the two solutions. These differences virtually disappeared, however, when the solution based on class means was re-rotated towards the solution based on individual students' responses. Table 4 shows the re-rotated loadings for the mean class responses, and Table 5 gives the item vector cosines, indicating the relationship between the 33 item vectors based on individual responses and the re-rotated vectors based on mean class responses. Table 6 lists the primary loadings for each of these solutions.

These data, then, indicate that the two data bases produce comparable solutions when the Eigenroot of 1.00 is used as the criterion for stopping factoring. The six factors obtained were identified as: I. General Course-Instructor Effectiveness, reflected by items related both to aspects of the instructor's teaching performance and competence and to general evaluation of the course content and methods; II. Student effort, reflecting the students' estimates of time, effort, and preparation required for the course; III. Expectations for the Course, including primary loadings for two items involving students' expectations and for an item cnncerning textbooks; IV. Direct Contact with Instructor, which included primary loadings for two items related to instructor's accessibility and to actual conferences with the instructor; V. Instructional Style, reflecting specific aspects of the instructor's preparation, performance, and demeanor; and VI. Evaluation and Planning, which picked up items related to tests and grading, and course pacing, as well as the item concerning reference books and library materials.

Although the factors obtained for the two data bases were similar, these six factors accounted for only 55% of the variance of individual responses, in contrast to 73% of the variance of mean class responses. In terms of the percentage of variance criterion for stopping factoring which was proposed here, there seemed to be little purpose in extracting more than six factors when mean responses were used. When factoring was extended, twelve factors were required to account for 70.35% of the variance of individual responses. This solution, moreover, appeared to add some clearly interpretable factors which further clarified the dimensions underlying ratings of courses and instructors. When, for purposes of comparison, twelve factors were obtained for the mean class data, 85% of the variance was extracted, but there were indications of increasing disintegration of the factor structure. As Table 6 shows, six of the factors (V, VI, VIII, IX, X, and XI) so obtained represented the factor of primary loading for only one item, and one factor (XII) had no primary loadings.

Table 7 shows the increases in latent roots and percentages of variance accounted for as increasing numbers of factors (from 1 to 12) are extracted for each data base. Although the percentages themselves are higher at each step for mean class responses, it should be noted that the gain in percentage of variance accounted for from six to twelve factors is somewhat higher for individual responses.

Inspection of loadings for the twelve factors based on individual students' responses resulted in the factors being labeled as follows: I. General Course Effectiveness; II. Student Effort; III. Expectations for Course; IV. Direct Contact with Instructor; V. Instructional Style; VI. Texts, References, and Materials; VII. Class Attendance; VIII. Instructor Empathy; IX. Instructor Mannerisms; X. Evaluation;

XI. Organization; XII. Value of Lab or Discussion Sessions.

Conclusions

Individual students' responses and mean class responses seem to provide comparable factor structures in terms of the large, general factors. When more specific and meaningful factors are sought, however, it is recommended that factoring be extended beyond the Eigenroot of 1.00 criterion, extracting factors until the variance accounted for is equal to the percentage of reliable test variance, or until the percentage of variance accounted for is increased as much as possible without producing factor fission.

The data presented here call attention to inappropriate use of the Eigenroot criterion in factor work, a practice which has probably grown out of a theoretical focus on determining basic laws of behavior, rather than a practical emphasis on providing information that will be useful to college instructors and administrators. When researchers have sought only the general, broad dimensions that occur in CIS ratings, instructors and administrators have consequently concluded that only these larger factors are needed in describing the evaluation of courses and instructors. In reality, however, administrative decision making and the provision of comprehensive feedback to instructors may demand that more specific factors be identified. In such cases, the proportion of variance criterion for stopping factoring may reveal information which would be lost were the Eigenroot criterion applied without regard to variance extracted. The question of when to stop factoring, then, seems to be best answered in terms of whether general laws of behavior are sought, or basic dimensions for specific practical applications.

When the proportion of variance criterion is used, smaller factors can be identified and expanded, which might otherwise have appeared as redundant items loading on the more general factors. The practice of

extracting only these larger factors, moreover, has sometimes led to speculation that considerable response bias exists in course and instructor ratings, often resulting in distrust of such ratings by instructors. Misapplied factor methodology, then, can result both in obscuring information and in limiting the use of CIS results. The current paper offers some guidelines which should facilitate more appropriate applications of factor analytic techniques within this area.

TABLE 1

VARIMAX FACTOR LOADINGS FOR ANALYSIS OF INDIVIDUAL STUDENTS' RESPONSES

Item Number	V Loadings					
	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
8	.5042	-.1680	-.0603	.3606	.3770	.2085
9	.1696	.1235	.0272	.0066	.7503	.2145
10	.2188	.1173	.0951	-.0199	.7355	.1038
11	.1932	.0789	.0293	.0092	.7269	.1216
12	.2270	-.0203	-.0182	-.0141	.4117	.4547
13	.0438	.0563	.0981	-.0433	.4982	.4069
14	.3969	-.0843	-.0540	.2336	.4420	.3219
15	.3313	-.0343	.0103	.1055	.5469	.3140
16	-.3244	.0943	.0328	-.1544	-.4268	.0618
17	.5142	-.0110	.0326	.1291	.5111	.1095
18	.4752	-.1918	-.0892	.3809	.1785	.2114
19	.6303	.0368	.1413	.1128	.4043	.1043
20	.4196	.0405	.1111	.2137	.4895	.1345
21	.1424	.0217	.0743	.6575	.1534	.3516
22	.2030	-.1210	.0187	.2183	.2622	.5807
23	.2521	-.0777	-.0344	.2861	.2192	.5820
24	.0102	.1097	-.0409	.1242	.1313	.6250
25	.5056	-.1019	-.0247	.0773	.1940	.4597
26	.3249	.0325	.3492	-.3063	.1047	.3182
27	.1848	.0524	.2602	-.1409	-.0009	.4331
28	.6117	.1932	.2317	-.0001	.1068	.3080
29	.4684	.1783	.3091	-.0209	.0332	.2419
30	.0247	.0483	.8605	.0006	.0334	-.0240
31	.1200	.0997	.8162	.0661	-.0013	.0563
32	.7180	.1472	.1827	.0269	.2608	.1984
33	-.0488	.7491	.1223	.0314	.1282	-.0676
34	.0461	.7591	.1221	.0863	.0791	.0478
35	.1925	.7513	.0444	.1099	.1430	.0104
36	.0713	.2741	.0243	.7074	-.0415	-.0095
37	.2096	.4096	-.2185	-.0587	-.1494	.1195
38	.6307	.0952	-.0126	.1359	.5587	.0802
39	.7019	.2120	.1364	-.0195	.3598	.0855
40	.7158	.1654	-.2358	.0082	.3047	.1461

TABLE 2

VARIMAX FACTOR LOADINGS FOR ANALYSIS OF MEAN CLASS RESPONSES

V Loadings

Item Number	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
8	.6442	-.1662	-.0984	.6091	.1027	.0742
9	.6798	.2359	-.1457	-.0684	.4984	-.1660
10	.7360	.2025	-.3143	-.0619	.2296	-.2010
11	.3530	.1978	-.0753	-.0832	.1491	-.0216
12	.4072	-.0444	-.0009	.0649	.5892	.2839
13	.1678	.0601	-.2944	-.0655	.6669	-.2204
14	.7274	-.0596	-.0134	.3510	.2278	.2262
15	.8000	.0075	-.0550	.1436	.3112	.1217
16	-.7125	.0129	.0840	-.2309	.0256	.1013
17	.8526	.0165	-.1593	.1073	.0338	.1315
18	.3997	-.2890	-.1334	.6516	-.0079	.0902
19	.7603	.1185	-.4546	.1933	-.0004	.0033
20	.6403	.1493	-.4145	.3466	.0740	-.0917
21	.1438	.2484	-.0334	.7065	.1999	-.0502
22	.3733	-.2817	-.1235	.3879	.5354	-.0142
23	.4631	-.1504	-.0026	.5544	.4398	.0425
24	.0622	.1648	.1509	.2712	.5568	.1866
25	.5011	-.2300	-.2864	.3846	.3460	.1010
26	.2799	-.0650	-.7116	-.1910	.1369	.0268
27	.2037	-.0489	-.5437	.0587	.0930	.4322
28	.5152	.2395	-.5253	.2227	.1568	.2344
29	.2338	.1980	-.6080	.3342	.1240	.0813
30	.0754	.1471	-.8620	-.0570	-.0960	-.2300
31	.0768	.3023	-.7729	.1155	-.0032	-.0561
32	.6661	.1786	-.4240	.2229	.2097	.1950
33	.0801	.8396	-.1996	-.0931	.0203	-.0147
34	.1588	.8105	-.2334	.0169	.0836	.1138
35	.3114	.8086	-.1960	.0150	.0807	.1539
36	.0007	.5827	.1094	.5572	-.1424	.1008
37	.0348	.3894	.0734	.0570	.0184	.7125
38	.8708	.1802	-.2556	.1925	.1128	.0913
39	.7239	.2344	-.5013	.1402	.1183	.1015
40	.7361	.1256	-.1088	.1839	.2368	.2173

TABLE 3

COSINES* AMONG FACTOR AXES
FOR 6-FACTOR SOLUTIONS USING INDIVIDUAL AND CLASS RESPONSES

Factors Based on Individual Responses	Factors Based on Mean Class Responses					
	I	II	III	IV	V	VI
1	.6355	-.1063	-.3659	.2618	-.3455	.5129
2	-.0164	.9371	-.0464	-.1521	.0654	.3032
3	-.1874	.1005	-.8789	.0404	-.0350	-.4227
4	-.0013	.2585	.2276	.8344	-.0375	-.2996
5	.7458	.1249	.0736	-.1854	.3641	-.5057
6	-.0673	-.1340	-.1854	.2938	.8562	.3475

* Cosines on the diagonal are directly interpretable as correlation coefficients between the two sets of factor loadings.

TABLE 4

VARIMAX LOADINGS FOR RE-ROTATED 6-FACTOR SOLUTION
BASED ON MEAN CLASS RESPONSES

Item Number	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
8	.6251	-.2252	-.0558	.4402	.3304	.2929
9	.1850	.2003	.0737	-.0324	.3038	.2982
10	.3625	.1557	.2325	-.0371	.7473	.0838
11	.4631	.1915	-.0738	-.0533	.7360	.0239
12	.2229	.0665	-.2174	-.0073	.3570	.6012
13	-.1526	.0539	.2993	-.1086	.4774	.5101
14	.6027	-.0371	-.2168	.2010	.4375	.3400
15	.5202	.0313	-.1561	.0466	.6137	.3070
16	-.5022	.0874	.0058	-.2136	-.5227	.0188
17	.7014	.0228	-.0658	.0803	.5391	.1048
18	.5531	-.3435	.0077	.4444	.0829	.2559
19	.6028	.0930	.2745	.0944	.5082	.0778
20	.5602	.0729	.3129	.2701	.4747	.1489
21	.1909	.1036	.0810	.7564	.0863	.3550
22	.2217	-.2927	.0167	.1937	.3643	.6049
23	.3263	-.1311	-.1055	.3946	.3623	.5465
24	-.0583	.1981	-.2127	.2065	.1361	.5684
25	.4006	-.2158	.0909	.1503	.3275	.4965
26	.3616	.0136	.5402	-.3694	.2200	.1913
27	.5385	.1043	.2517	-.2233	-.0898	.3410
28	.6135	.2878	.2956	.0531	.2727	.3129
29	.4363	.1918	.4883	.1716	.0964	.3048
30	.2479	.1092	.3560	-.1304	.1031	-.0441
31	.3020	.2031	.7248	.0214	.0439	.1099
32	.6454	.2150	.1870	.0671	.4243	.3238
33	-.0043	.3058	.2457	.0916	.1820	-.0965
34	.1340	.8052	.2066	.1289	.1722	.0401
35	.2388	.8113	.1280	.1240	.2674	.0343
36	.1453	.4775	-.0478	.6520	-.1248	-.0188
37	.3596	.5687	-.3403	-.0475	-.2469	.2089
38	.6360	.1722	.0465	.1192	.6124	.1505
39	.6664	.2482	.2884	.0276	.4980	.1913
40	.6041	.1634	-.1303	.0810	.5359	.2838

TABLE 5

COSINES BETWEEN ITEM VECTORS FOR SIX FACTORS
BASED ON INDIVIDUAL AND MEAN CLASS RESPONSES

Item No.	Item Vector Cosine	Item No.	Item Vector Cosine
8	.9908	25	.9704
9	.9919	26	.9517
10	.9763	27	.8532
11	.9324	28	.9736
12	.9366	29	.9390
13	.9242	30	.9535
14	.9601	31	.9418
15	.9600	32	.9653
16	.9679	33	.9864
17	.9814	34	.9856
18	.9639	35	.9880
19	.9889	36	.9543
20	.9662	37	.9946
21	.9836	38	.9928
22	.9740	39	.9694
23	.9674	40	.9332
24	.9434		

TABLE 6

COMPARISON OF PRIMARY LOADINGS FOR FACTOR SOLUTIONS OF SIX AND TWELVE FACTORS DERIVED FROM TWO DATA BASES

SIX-FACTOR SOLUTIONS				TWELVE-FACTOR SOLUTIONS			
Individual Responses		Class Averages*		Individual Responses		Class Averages	
Factor I				Factor I			
32	.7180	17	.7014	40	.7430	11	.8754
40	.7158	19	.6928	32	.7346	38	.8438
39	.7019	38	.6860	39	.7302	10	.8403
38	.6307	39	.6664	28	.5978	17	.7781
19	.6303	32	.6454	38	.5580	9	.7763
28	.6117	8	.6251	19	.4837	15	.7575
17	.5412	28	.6185			40	.7506
25	.5056	40	.6041			19	.7374
8	.5042	14	.6027			39	.7095
18	.4752	20	.5609			20	.6518
29	.4684	18	.5531			32	.6332
		27	.5385			14	.6004
						28	.4811
Factor II				Factor II			
34	.7591	33	.8058	33	.8257	33	.8257
35	.7513	34	.8052	34	.8039	34	.8039
33	.7491	35	.8113	35	.7506	35	.7506
37	.4096	37	.5607				
Factor III				Factor III			
30	.8605	30	.8560	30	.8716	30	.9058
31	.8162	31	.7248	31	.8701	31	.8355
26	.3492	26	.5409			29	.5941
		29	.4883			26	.5420
Factor IV				Factor IV			
36	.7074	21	.7564	36	.8767	36	.8653
21	.6575	36	.6520	21	.6753	21	.7676
Factor V				Factor V			
9	.7508	9	.8038	10	.7642	13	.8834
10	.7355	10	.7478	9	.7452		
11	.7269	11	.7369	11	.7305		
15	.5469	15	.6187	17	.4774		
13	.4982	16	.5227	20	.4721		
20	.4895			15	.4649		
14	.4420						
16	.4268						

SIX-FACTOR SOLUTIONS

Individual Responses		Class Averages	
Factor VI			
24	.6250	22	.6049
23	.5820	12	.6012
22	.5807	24	.5684
12	.4547	23	.5465
27	.4321	13	.5101
		25	.4965

TWELVE-FACTOR SOLUTIONS

Individual Responses		Class Averages	
Factor VI			
27	.8813	37	.9032
26	.5749		
Factor VII			
37	.9464	22	.3139
		13	.7404
		23	.7234
		25	.6306
		8	.6243
Factor VIII			
18	.7734	27	.9040
8	.6475		
14	.5933		
23	.5115		
25	.4637		
Factor IX			
16	.3900	24	.9448
Factor X			
24	.8865	12	.7436
Factor XI			
13	.7075	16	.6584
22	.5461		
12	.5161		
Factor XII			
29	.8096		

* Re-rotated Solution.

TABLE 7

Variance Accounted for by Successive Principal Axes

Data Based on Individual Student Responses

Factors	Size of Latent Root	Difference From Previous Latent Root	Cumulative Latent Roots	Cumulative % of Total Variance Accounted for
I	9.97		9.97	30.21
II	2.56	7.41	12.53	37.84
III	1.79	.77	14.32	43.27
IV	1.50	.29	15.82	47.82
V	1.27	.23	17.09	51.63
VI	1.13	.14	18.22	55.09
VII	.93	.20	19.15	57.90
VIII	.94	.01	20.09	60.74
IX	.80	.14	20.89	63.16
X	.84	.04	21.73	65.71
XI	.81	.03	22.54	68.17
XII	.72	.09	23.26	70.35

Data Based on Average Class Responses

I	13.69		13.69	41.50
II	3.71	9.98	17.40	52.73
III	2.43	1.28	19.83	60.09
IV	1.82	.61	21.65	65.60
V	1.34	.48	22.99	69.79
VI	1.04	.30	24.03	72.94
VII	.86	.18	24.89	75.55
VIII	.76	.10	25.65	76.84
IX	.77	.01	26.45	79.18
X	.72	.05	27.17	82.37
XI	.57	.15	27.74	84.08
XII	.59	.02	28.33	85.85

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